Chapter 6

Conclusions and Discussion

The National Sediment Inventory (NSI) database is EPA's largest compilation of sediment chemistry data (measuring the chemical concentration of sediment-associated contaminants); tissue residue data (measuring chemical contaminants in the tissue of organisms); and toxicity data (measuring the lethal and sublethal effects of contaminants in environmental media on various test organisms). This database contains environmental monitoring data from a variety of sources (e.g., state and federal monitoring programs) and includes more than 4.6 million analytical observations and 50,000 stations throughout the United States from 1980 to 1999. For this report, EPA presents the results of the screening-level assessment of the NSI data from 1990 to 1999. The purpose of this assessment was to determine whether potential adverse effects to aquatic life and human health from sediment contamination either exist currently or existed over the past 10 years at distinct monitoring locations throughout the United States. One major advantage of screening out older data (data collected prior to January 1, 1990) is to prevent the results presented in this report from being unduly influenced by historical data when more recent data are available. This would not allow the results of any decrease in sediment contaminant levels due to scouring, re-burial, natural attenuation, or active sediment remediation that have occurred since that sample was collected.

EPA evaluated a total of 19,470 sampling stations nationwide as part of the NSI data evaluation. Of these sampling stations, 7,600 (39 percent) were classified as Tier 1 (associated adverse effects on aquatic life or human health are probable); 6,281 (32 percent) were classified as Tier 2 (associated adverse effects on aquatic life or human health are possible); and, 5,589 (29 percent) were classified as Tier 3 (no indication of associated adverse effects). As was pointed out earlier in the document, many sampling programs target only sites of known or suspected contamination. This factor could contribute significantly to the high percentage of Tier 1 classifications. To further evaluate this, an evaluation was conducted using the same tiering methodology on data collected from the EPA's Environmental Monitoring and Assessment Program (EMAP). This program uses a probabilistic sampling design and selects sampling locations at random. This analysis revealed that only 26 percent of EMAP sampling stations were classified as Tier 1; 45 percent were classified as Tier 2; and, 29 percent were classified as Tier 3. This would suggest that state monitoring programs (accounting for the majority of the NSI data) have tended to focus their sampling efforts on areas where contamination is known or suspected to occur. Further evaluation of the effects of nonrandom sampling design on the frequency of detecting contaminated sampling stations can be found in Swartz et al. (1995). They compared the percent of sediment sampling stations that exceeded PAH screening levels (ERL, SQC, AET) based on random sampling station selection (Virginia Province EMAP stations) to the percent of sampling stations that exceeded those levels based on sampling station selection on the basis of known PAH contamination (such as creosote-contaminated Eagle Harbor, Washington). The investigators found that the frequency of exceeding a sediment screening value in sampling stations known to be contaminated was 5 to 10 times greater than for randomly selected sampling stations.

In addition to the baseline screening-level assessment on the extent and severity of sediment contamination throughout the United States, EPA also used the data in the NSI to evaluate potential trends in sediment contaminant levels throughout the country. Despite the various limitations imposed by a lack of routine monitoring information outlined in Chapter 4, EPA developed an approach to provide a means for assessing changes in the extent and severity of sediment contamination over time for specific areas where sufficient data exists in the NSI database. When looking at each hydrologic region (defined as a major geographic area containing either the drainage area of a major river, such as the Missouri region, or the combined drainage areas of a series of rivers, such as the Texas-Gulf Region, which includes a number of rivers draining into the Gulf of Mexico) with sufficient data, focusing on those stations with more concentrated data sets, the results suggest that there has been a slight decrease to no change in the levels of sediment contamination (as measured by the predicted proportion toxic using the logistic model) from 1980 to 1999. The results for these individual hydrologic regions are presented in Chapter 4. Also discussed in Chapter 4 are the results from the USGS National Water-Quality Assessment (NAWQA) program that collected and analyzed sediment cores in lakes and reservoirs throughout the United States. Results from this analysis suggest that DDT (from 1965 through 1990) and lead (from 1970 through 1990) sediment concentrations displayed significant decreasing trends in several of the lakes and reservoirs studied from . These decreases appear to be linked to the banning of DDT in 1972 and the switching to unleaded gasoline in the 1970s. This analysis of sediment cores also demonstrated a significant increase in sediment PAH levels that appears to be correlated with an increase in urbanization.

The characteristics of the NSI data, as well as the degree of certainty afforded by available assessment tools, allow neither an absolute determination of adverse effects on human health or aquatic life at any location, nor a determination of the areal extent of contamination on a national scale. However, the evaluation results strongly suggest that sediment contamination is significant enough to pose potential risks to aquatic life and human health in various locations throughout the United States. The evaluation methodology was designed for the purpose of a screening level assessment of sediment quality. Further evaluation should be conducted to confirm the extent and severity of sediment contamination for any given site or watershed.

Based on the number and percentage of sampling stations containing contaminated sediment within watershed boundaries, EPA identified a number of watersheds containing areas of probable concern (APCs) for sediment contamination where additional studies may be needed to draw conclusions regarding the need for actions to reduce risks. About 18 percent of the watersheds in the contiguous United States (370 out of 2,111) met the requirements outlined in Chapter 3 and were designated to contain an APC. Although the APCs were selected by means of a screening assessment, EPA believes that they represent the highest priority for further ecotoxicological assessments, risk analysis, and contaminant source evaluation because of the increased weight-of-evidence in these areas. Although the procedure for classifying APCs using multiple sampling stations was intended to minimize the probability of making an erroneous classification, further monitoring of conditions in watersheds containing APCs is necessary because the same mitigating factors that might reduce the probability of associated adverse effects at one sampling station may also affect neighboring sampling stations.

EPA chose the watershed as the unit of spatial analysis because many states and federal water and sediment quality management programs, as well as data acquisition efforts, are centered on this unit. This choice reflects the growing recognition that activities taking place in one part of a watershed can greatly affect other parts of the watershed, and that management efficiencies are achieved when viewing the watershed holistically. At the same time, the EPA recognizes that contamination in some reaches in a watershed does not necessarily indicate that the entire watershed is affected. Further analysis should be conducted within that watershed to delineate sediment contamination which would allow any sediment management activities determined to be necessary be done in the most effective (cost as well as environmentally) and sound manner.

Watershed management is a critical component of community-based environmental protection using watershed or hydrologic boundaries to define the problem area. Many public and private organizations are joining forces and creating multi-disciplinary and multi-jurisdictional partnerships to focus on water quality problems, community-by-community and watershed-by-watershed. These watershed approaches are likely to result in significant restoration, maintenance and protection of water resources throughout the United States. As was reported in the initial *National Sediment Quality Survey* in 1997, various programs across the United States as part of the National Estuary Program have used a watershed approach that has led to specific actions to address contaminated sediment problems. These include the Narragansett (RI) Bay, Long Island Sound, New York/New Jersey Harbor, and San Francisco Bay Estuary programs.

These specific programs have all recommended actions to reduce sources of toxic contaminants to sediment.

As part of EPA's *Contaminated Sediment Action Plan*, the Office of Solid Waste and Emergency Response (OSWER), the Office of Water (OW), and the EPA's Regional Offices will initiate a pilot project to facilitate cross-program coordination on contaminated sediments. The pilot project will bring a cross-Agency focus to identifying and assessing waters that are impaired by sediment contamination. The pilots will utilize the legal authorities and techniques available to both programs to satisfy the needs of both the Remedial Investigation/Feasibility Study (RI/FS) evaluations and Total Maximum Daily Load (TMDL) modeling. The ultimate goal of the pilots is to develop more watershed-based approaches to identifying and assessing contaminated sediments. EPA will work with other Federal agencies, States, and interested stakeholders as these pilots are identified and implemented.

The remainder of this chapter presents some general conclusions about the extent and severity of sediment contamination in locations throughout the United States as well as potential sources of sediment contaminants. It also looks at conclusions from other studies addressing regional as well as national extent of sediment contamination. Finally, this chapter discusses other studies indicating sediment contamination.

Extent of Sediment Contamination

Based on EPA's evaluation, sediment contamination exists at levels where associated adverse effects are probable (Tier 1) in some locations within each region of the country. The waterbodies affected include streams, lakes, harbors, nearshore areas, and oceans. A number of specific areas in the United States had large numbers of sampling stations where associated adverse effects are probable. Puget Sound, Elliot Bay, Hudson River, Pacific Ocean (near Santa Monica and San Diego), Willamette River, Sinclair Inlet, San Diego Bay, Bellingham Bay, San Francisco Bay, Sheboygan River, Passaic River, Christina River, Mississippi River, Big Creek (Grays Harbor), and Duwamish Waterway were among those locations. Based on the above list, several harbors appear to have some of the most severely contaminated sediments in the country. This finding is not surprising since major harbors have been affected throughout the years by large volumes of boat traffic, contaminant loadings from upstream sources, and many local point and nonpoint sources.

Thousands of waterbodies in hundreds of watersheds throughout the country contain sampling stations classified as Tier 1. Many of these sampling stations may represent isolated "hot spots" rather than widespread sediment contamination, although insufficient data were available in the NSI database to make such a determination. EPA's River Reach File 1 (RF1) delineates the Nation's rivers and waterways into segments or reaches of approximately 1 to 10 miles in length. Based on RF1, approximately 8.8 percent of all river reaches in the contiguous United States contained NSI sampling stations. More than 7,500 sampling stations in approximately 2,100 river reaches across the country (3.3 percent of all reaches) were classified as Tier 1. Nearly 6,300 sampling locations were classified as Tier 2. In total, over 4,000 river reaches in the United States—approximately 6.3 percent of all river reaches—include at least one Tier 1 or Tier 2 station.

EPA cannot determine the areal extent or number of river miles of contaminated sediment in the United States from the data in the NSI. This is due to: 1) the NSI database not providing a complete coverage for the entire nation; 2) sampling locations are largely based on a nonrandom sampling design; and, 3) sediment quality can vary greatly within very short distances.

The results of the NSI data evaluation discussed in this report must be interpreted in the context of data availability. Many States and Regions appear to have a much greater incidence of sediment contamination than others. To some degree, this appearance reflects the relative abundance of readily available electronic data, not necessarily the relative incidence of sediment contamination. For example, 2,600 sampling stations in Region 10 (AK, ID, OR, WA) are designated as Tier 1, whereas only 74 sampling stations in Region 8 (CO, MT, ND, SD, UT, WY) are designated as Tier 1. However, out of the 19,470 sampling stations evaluated from 1990 to 1999 throughout the United States only one and a half percent (294) were located in Region 8 while 27 percent (5,330) were located in Region10. Therefore, although the absolute number of Tier 1 and Tier 2 stations in each state is important, relative comparisons of the incidence and severity of sediment contamination between states is not possible because the extent of sampling and data availability vary widely.

For a number of reasons, some potentially contaminated sediment sites were missed in this evaluation. The most obvious reason is that the NSI database does not include all the sediment quality data collected throughout the United States from 1990 to 1999. EPA is continually updating the NSI database for future evaluations to provide a better national coverage. In addition, some data in the NSI database were not evaluated because of questions concerning the data quality or because information regarding the location of the samples (i.e., latitude and longitude) was not available.

Sources of Sediment Contamination

Toxic chemicals that accumulate in sediment and are associated with adverse effects to aquatic and human health enter the environment from a variety of sources. These sources can be separated into point sources and nonpoint sources. The term “point source” is defined by the Clean Water Act (CWA) and generally refers to any specific conveyance, such as a pipe or ditch, from which pollutants are discharged. In contrast, nonpoint sources do not have a single point of origin and generally include diffuse sources, such as urban areas or agricultural fields, that tend to deliver pollutants to surface waters during and after rainfall events. Some sources, such as landfills (including confined disposal facilities [CDF] containing dredged sediments) and mining sites, are difficult to categorize as either a point or nonpoint source. Although these land areas represent discrete sources, pollution from such areas tends to result from rainfall runoff and leaching. Likewise, atmospheric deposition of pollutants, generally considered to be a nonpoint source of water pollution, arises from the emission of chemicals from discrete stationary and mobile source points of origin. The CWA specifies water vessels and other floating craft as point sources although, taken as a whole, they function as a diffuse source.

Many point and nonpoint pollutant sources have been the subject of federal and other action over the past 25 years. The direct discharge of pollutants to waterways from municipal sewage treatment and industrial facilities requires a permit under the CWA. The authority to issue such permits has been delegated to many states by the EPA. These permits contain technology-based and water quality based pollutant discharge limits and monitoring requirements. The disposal of sediment dredged to maintain navigation channels is managed under both the CWA and the Marine Protection, Research, and Sanctuaries Act (MPRSA) to ensure that unacceptable degradation from chemical pollutants in the dredged material does not occur at the disposal location. Emission standards and controls on stationary and mobile sources of air pollutants have also been established in federal regulations promulgated under the authority of the Clean Air Act (CAA). These actions have reduced emissions of gaseous compounds such as inorganic oxides, as well as pollutants that eventually enter waterbodies and accumulate in sediment. The Toxic Substances Control Act (TSCA) and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) have greatly reduced the toxic pollutant input to the environment through bans and use restrictions on many pesticides and industrial-use chemicals.

The combined impact of these actions has yielded improvements in water quality. We see a lag in the improvement of sediment quality compared to water quality due to the persistent nature of many pollutants, especially since sediments acts as a reservoir for many contaminants. Other factors include the difficulty in monitoring and regulating most toxic bioaccumulative pollutants. As was discussed earlier in this chapter and outlined in detail Chapter 4, several hydrologic regions across the United States exhibited a slight decrease in the levels of sediment contamination (as measured by the predicted proportion toxic using the logistic model). One possible explanation as to why more regions did not exhibit decreasing trends or why more dramatic trends were not observed could be due to the under-representation of uncontaminated areas in the NSI database.

Natural recovery of contaminated sediment can occur through source reduction, contaminant degradation, and continuing deposition of clean sediment or the "burial" of contaminated sediments. The feasibility of natural recovery, as well as the long-term success of remediation projects, depends on effective pollutant source control. For some classes of sediment contaminants, such as PCBs and organochlorine pesticides, use and manufacture bans or severe restrictions have been in place for many years. Past disposal of PCBs continue to result in evaporation of these contaminants from some landfills and leaching from soils, but most active PCB sources have been controlled. The predominant sources of organochlorine pesticides are runoff and atmospheric deposition from past applications on agricultural land, and occasional discharge from municipal treatment facilities. For other classes of sediment contaminants, active sources continue to contribute environmental releases. For example, the release of inorganic mercury from fuel burning and other incineration operations continues, as do urban runoff and atmospheric deposition of metals and PAHs. Although, great strides have been made in reducing these inputs. For example, substantial reductions have been recognized in air emissions from the Maximum Available Control Standards (MACT) for Hazardous Air Pollutants (HAP), established under Section 112 and Section 129 of the Clean Air Act. Overall, the MACT standards achieve at least 50 percent reduction in air toxics emissions (Tables 6-1 and 6-2) and some 1.5 million tons/year of toxics will be removed due to this program. In addition, point source discharge limits are based on technology-based limits and state-adopted standards for protection of the water column and are not designed for the protection of sediment quality.

Table 6-1. Example MACT Estimated Mercury Emission Reductions.

Mercury Source Categories	1990 Inventory	Estimated Reductions
Coal-Fired Utility Boilers	25%	uncertain
Medical Waste Incinerators	24%	98%
Municipal Waste Combusters	20%	90%
Chlorine Production	6%	92%
Industrial Boilers	6%	25%

Table 6-2. Example MACT Estimated Air Toxics Emission Reductions.

Municipal Waste Combuster (MWC)	2001[a]	2005[b]
Dioxins/Furans	99%	99+%
Lead	77%	94%
Cadmium	68%	78%

[a] Large MWC compliance date
[b] Small MWC compliance date

Other Studies Evaluating the Extent of Sediment Contamination

In 1997, the U.S. Department of Agriculture (USDA), the EPA, and seven other federal agencies developed a Clean Water Action Plan that charts a course toward fulfilling the original goal of the CWA - "fishable and swimmable" waters for all Americans. One of the actions in this plan was for the development of a comprehensive report on the condition of the nation's coastal waters. In support of this action, the EPA has developed a report entitled the *National Coastal Condition Report* (USEPA, 2002). The report is available at EPA's website at http://www.epa.gov/owow/oceans/nccr/index.html or copies are available by calling 1-800-490-9198. Key contributors to this draft report were the National Oceanic and Atmospheric Administration (NOAA), the Department of the Interior (the U.S. Fish and Wildlife Service), as well as several other local, state and federal agencies.

One of the indicators used in this report to assess the conditions of the Nation's coastal waters was sediment contamination. National and regional monitoring programs conducted by EPA [EMAP for estuaries (EMAP-E)] along with NOAA's National Status and Trends program provided the data evaluated in the sediment contamination indicator. This indicator was evaluated using the NOAA Effects Range-Medium (ERM) and Effects Range-Low (ERL) values (Long and Morgan, 1990) where ERM values are the concentration of contaminants that will result in ecological effects 50 percent of the time and ERL values are the concentration of contaminants that will result in ecological effects 10 percent of the time. An estuary was determined to be in "poor" condition if it exceeded one (1) ERM values or five (5) ERL values.

The geographic regions analyzed included the: Northeast Coast, Southeast Coast, Gulf of Mexico, West Coast, and the Great Lakes. Although the objective of the report was to evaluate the condition of coastal resources (in this case primarily estuaries) on a national level, there is sufficient information to assess only Northeastern, Southeastern, and the Gulf of Mexico estuaries. Partial assessments are possible for the West Coast estuaries and the Great Lakes, and no assessment is currently possible for the estuarine systems of Alaska, Hawaii, and island territories (USEPA, 2002). Results from this report indicate that the overall condition of the sediments throughout the estuaries and the Great Lakes of the United States would generally be classified as poor. Probabilistic surveys conducted by EPA's EMAP-E, outlined in the *National Coastal Condition Report*, allowed for the spatial estimates of ecological condition for the following regions: Northeast, Southeast, and the Gulf of Mexico. This spatial estimate was expressed as a percent of degradation measured as the percentage of total estuarine surface area in the region (or nation).

Results from the Northeast Coast indicate that 41 percent of the estuaries are degraded as a result of sediment contamination. Results of the percent area degraded from the Southeast Coast and the Gulf of Mexico due to contaminated sediments is 13 percent and 43 percent respectively. The national estimate of estuarine areas degraded due to contaminated sediments is 35 percent (USEPA, 2002). Even though probabilistic surveys were not conducted in the Great Lakes and in the West Coast estuaries to allow for spatial estimates of sediment contamination, existing monitoring data from various programs is available to assess the condition of the sediments. EPA's Great Lakes National Program Office (GLNPO) has determined that polluted sediments remain as the largest major source of contaminants to the Great Lakes food chain, and that over 2000 miles (20 percent) of the shoreline are considered impaired because of sediment contamination. Studies conducted on the West Coast show that sediment contaminant conditions in the Southern California Bight (SCB) are poor. Using ERL and ERM values, it was determined that 67 percent of the sediments in the SCB have contaminants that could potentially result in adverse ecological effects.

As was highlighted in Chapter 1, NOAA performed toxicity tests on 1543 surficial sediment samples collected from 1991 through 1997 from estuaries and bays along the Atlantic, Gulf of Mexico, and Pacific coasts. These samples encompassed an area approximately 7300 km^2. Toxicity was observed in samples that represented approximately 6 percent of the combined area (Long, 2000) when using amphipod lethality tests. Toxicity was considerably much more widespread (25 percent to 39 percent), however, when the results of two sub-lethal sediment toxicity assays were evaluated (Long, 2000). It has been demonstrated that in some cases longer-term sediment toxicity tests in which survival and growth are measured tend to be more sensitive than shorter-term tests, with chronic toxicity 6 times higher than acute toxicity as indicated for *Hyalella azteca* (Ingersoll et al., 2000).

Other Studies Indicating Sediment Contamination

The EPA's National Fish and Wildlife Contamination Program provides technical assistance to State, Federal, and Tribal agencies on matters related to health risks associated with dietary exposure to chemical contaminants in fish and wildlife. Human and wildlife consumption of finfish and shellfish that have accumulated contaminants in their tissue (bioaccumulation) is an important human health and wildlife concern. In fact, fish consumption represents the most significant route of aquatic exposure of humans to many metals and organic compounds (USEPA, 1992). Most sediment-related human exposure to contaminants is through indirect routes that involve the transfer of pollutants out of the sediment and into the water column or aquatic organisms. Many surface waters have fish consumption advisories or fishing bans in place due to mercury as well as a group of bioaccumulative contaminants (PCBs, chlordane, dioxins, and DDT and its metabolites [DDD and DDE]) that are commonly found in sediments based on the NSI database. Based on EPA's national Listing of Fish and Wildlife Advisories database (NLFWA) there are more than 2,800 fish advisories in the United States for the types of contaminants (such as the ones listed above) often found in contaminated sediments. These advisories affect over 325,000 river miles, 71 percent of the Nation's Coastal Waters, and more than 63,000 lakes, including 100 percent of the Great Lakes. The numbers of advisories in the United States in 2000 represents a 7 percent increase over 1999, and a 124 percent increase since 1993. This increase in advisories issued by the states generally reflects an increase in the number of assessments of contaminants in fish and wildlife tissues.